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The role of instruments in the contemporary cosmological paradigm

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Instruments and technological methods have become the main evidence base in physical science, with the key concepts of research becoming detection, discovery, and identification. The technological component of the study has become predominant in a way that is argued for here. This requires contrasting the current standard cosmological model, Lambda Cold Dark Matter (ΛCDM), and alternative constructions to it, such as Modified Newtonian Dynamics. We will look at some of the reasons why alternative theories do not get enough attention in scientific communities or communities related to the financing of scientific research.

The standard cosmological model, ΛCDM, postulates the existence of two hypothetical objects - dark matter and dark energy. Dark matter was introduced to scientific theory to explain the rotation velocities of objects at the peripheries of individual galaxies. Theoretical predictions do not fit our observations, and observed baryonic matter is insufficient to account for this discrepancy. Therefore, by postulating the existence of dark matter, ΛCDM causes the problem of "direct detection" of dark matter. (Philosophers of science prefer to use the term "independent detection," i.e. detection by measurement, which does not presuppose the theory it is meant to confirm. However, "direct detection" is still commonly used in cosmological and astrophysical literature to refer to the same thing). Alternative theories require the reconstruction of the theory of dynamics, but they do not involve the postulation of hypothetical objects and therefore do not suffer from the problem of its direct detection. On the other hand, they require much more theoretical work.

The claim defended in this paper is that the community of researchers working within the current cosmological paradigm have a methodological preference for an indefinitely modifiable theory that can be confirmed, but not falsified, with the help of highly developed and specialized technology, over competing theories which are falsifiable.

This claim is supported by three main considerations: 1) the theory proposed by the current paradigm is not more empirically successful than its rivals, 2) there are no successful a priori methodological arguments against the rivals of the current paradigm, and 3) the current paradigm, but not its rivals, has produced a theory which can be confirmed, but not falsified, through laboratory experiments which require high developed and specialized technology.

However, the claim here is that the promise of "direct detection" with the help of cutting-edge technology has a particular appeal for contemporary cosmologists, which explains the lack of interest toward its rivals despite considerations 1, 2 and 3. This is a rare, if not unique, situation in the physical sciences.

In addition to astronomical observations, there have been several attempts to detect dark matter candidate particles in underground laboratory settings. Generally, detection techniques have been designed with the detection of weakly interacting massive particles (WIMPs) in mind, although the data collected by the detectors is sometimes also analyzed in search of axion-like particles (ALPs) (for example, see n3).

The DAMMA/LIBRA collaboration is one of the oldest on-going detector experiments, located in the Laboratori Nazionali del Gran Sasso (LNGS). Sodium iodide crystals are used in this detector, one reason being that they do not have to be replaced often, meaning that the experiment can run uninterrupted for long times. The collaboration has claimed to have detected collisions between the crystals and dark matter every year since its operation. However, few researchers outside the collaboration have reacted enthusiastically to these claims, as it is widely claimed that other explanations cannot be ruled out based on the data released by DAMMA/LIBRA, and furthermore, that the results from DAMMA/LIBRA are in tension with those of other experiments. (n3)

Another type of detection technology is based on the use of noble gases, usually xenon, in liquid form. This type of material is notable for its homogeneity, and a pools ranging from dozens to thousands of kilograms is used at a time, providing a larger target for the hypothetical particles to collide with. The transparent liquid gas medium acts as scintillator for particles that collide with it, re-emitting the absorbed energy as a flash of ultraviolet light, which the detector shifts to the visible spectrum. This technique is thought to discriminate well between background noise and collision between dark matter particles and the detector medium, but an even more discriminating technique involves the use of both phases (gas and liquid) as a detector medium.

None of these of types of experiments has detected a dark matter candidate particle, and the popularity of the main candidates (WIMPs and ALPs) is beginning to decline. (n2) However, there is hardly a lack of available candidates, as new theoretical models of hypothetical particles are constantly devised to fit the most recent data (see, for example, n1). That dark matter is particulate is almost taken for granted by those working in the ΛCDM paradigm. (n4)

Indeed, this indefinite modifiability of the dark matter hypothesis and the general nature of existential statements leads to the conclusion that, although well defined models can be falsified - and are falsified all the time -, as a whole the existence of this hypothetical object is pragmatically verifiable but unfalsifiable. (See n4) Whether this, by itself, ought to be considered a great weakness of the theory depends on one's general views on the philosophy of science.

Nevertheless, the costliness of the experimental setups for "directly" detecting dark matter has raised the question among the most important funding agencies regarding the extent to which the hypothesis ought to be pursued. The cost of building an individual detector such as PandaX is around 15 million dollars- a significant investment of (mostly) public funds. Although the funding situation was described "terrible" by a prominent researcher already a few years ago (n5), the continued investments in and operation of underground dark matter detectors are a testament to the public appeal of such collaborations.

If the standard cosmological model lacked objectively credible rivals, the continued running of detection experiments could be explained by a lack of alternatives. However, the problems that motivated the dark matter hypothesis also gave rise to phenomenological descriptions of the mass discrepancy-acceleration relation, which are not less empirically successful than ΛCDM.

A hypothesis that explains the phenomenon is that researchers working in the

ΛCDM paradigm are driven to seek evidence through detector experiments, because no other independent confirmation of ΛCDM is available. The result is a community that favors detector experiments over other independent evidence, which turns attention away from competitors to the ΛCDM paradigm. Thus, a circular pattern of reasoning is formed. The scientific community prefers "tangible" results of the research over mere "theoretical activity".

References

1) Hecht, J. Dark matter: What's the matter? // Nature 537: S194–S197. 2016
2) Liu Jianglai, Chen Xun & Ji Xiangdong. Current status of direct dark matter detection experiments // Nature Physics 13: 212–216. 2017
3) Marrodán Undagoitia, T. & Rauch, L. Dark matter direct-detection experiments // Journal of Physics G 43: 1–78. 2016
4) Merritt, D. Cosmology and Convention // Studies in History and Philosophy of Modern Physics 57: 41-52. 2017
5) Reich, E. S. Dark-matter hunt gets deep // Nature 494: 291–292. 2013